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CANOPY ARTHROPOD DIVERSITY IN A NEW CALEDONIAN PRIMARY FOREST SAMPLED BY FOGGING[1]

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Abstract.—We collected 9608 specimens during three fogging samples in a New Caledonian rainforest. The most abundant arthropod taxa in number of specimen were Collembola, Diptera, Coleoptera, Hymenoptera and Psocoptera. The fogging in New Caledonia indicated a high percentage of Psocoptera and Diptera; however the effects of sample biases should be assessed before any comparison can be drawn.

Key Words.—Arthropoda, biodiversity, canopy, fogging, New Caledonia

Fogging as a collecting technique was first employed in 1966 by Martin (Erwin 1983). Since then, numerous studies of canopy arthropods have used this technique: in Ontario (Martin 1966), Costa Rica (Roberts 1973), Hawaii (Gagné 1979), Panama (Erwin & Scott 1980), South Africa and Great Britain (Southwood et al. 1982), Amazonia (Erwin 1983, 1989; Adis et al. 1984), Japan (Hijii 1983, 1986), Borneo (Stork 1987, 1988, 1991), Sulawesi (Noyes 1989), Thailand (Watanabe & Ruaysoongnern 1989) and Australia (Basset 1988, 1990, 1991). However, few studies dealt with the arthropod fauna of West Pacific islands and no comparison among arthropod faunas of the locations listed above has been attempted.

New Caledonia includes 3.5% of the area covered by extant tropical rainforests, and is one of the 10 "hot spots" identified by Myers (1988) on the basis of its species diversity and fragility. Studies of the fauna and flora from the Rivière Bleue reserve by the Muséum National d'Histoire Naturelle and ORSTOM show high endemicity (80% of animal species, 73% of plant species).

The present study determined the composition of the arthropod fauna from the tree crowns in the rainforest of the Rivière Bleue Reserve sampled by insecticidal fogging.

Methods and Materials

Study Area.—Samples were gathered in the Rivière Bleue reserve (20° S, 166° E), which has been a territorial park since May 1980. Geological and floristic characteristics of the location were described by Bonnet de Larbogne et al. (1991). The reserve is located in the great Southern massif of New Caledonia in the region of the Haute Yaté basin. The study was carried out in evergreen forest on alluvium in the flat bottom of the valley, 50 m from the river at a mean altitude of 160 m; this parcel is occasionally flooded.

Samples.—Fogging was carried out from the ground with a Dyna-fog Golden eagle backpack 2980, using a mixture of 200 cc cyfluthrin in water and polyhydric

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alcohols (Solfac EW 050) in 2 liters Maxifog solvent. Each fogging lasted 15 min. The collecting surface was arranged in six rows of five white plastic sheets of 1 m^2, separated by 0.5 m, giving a total surface area of 60 m^2. One half was placed on the soil and the other half on stands, 50 cm above the soil. The specimens that fell on the sheets were collected either by brushing (first fogging) or by washing with water (second and third fogging).

Three fogging samples were collected: the first (Fog1) and second (Fog2) in the same place, and the third (Fog3) 100 meters away. The first fogging (18 Jan 1991, 20° C, hygrometry: 90%) took place during the rainy season, the second (23 Jul 1991, 22° C, hygrometry: 85%) and third ones (1 Aug 1991, 20° C, hygrometry: 90%) during the dry season. Fog3 was carried out one week after Fog2. The aim was to sample the biotope, not particular tree species.

All arthropods were sorted at least to order level, and to family level for the most abundant orders: Hymenoptera, Diptera, Coleoptera in Fog1 and Fog3 and Orthoptera, Hemiptera in Fog1. When taxonomic expertise was available and in order to allow ecological and trophic precision, some families from Fog1 were sorted into subfamilies and tribes (Staphylinidae), species (Formicidae) and trophic guilds (Cecidomyiidae). The Collembola were sorted to species in the three foggings.

Results

Faunistic Composition.—Over the three foggings, 9608 specimens were collected (106.76 specimens/m^2) belonging to 107 families within 20 orders: 2227 in Fog1 (74.23/m^2), 3191 in Fog2 (106.37/m^2) and 4190 in Fog3 (139.67/m^2). These seem low when compared with other fogging samples: 35 to 161/m^2 in Amazonian samples (Adis et al. 1984), and 51 to 218/m^2 in Bornean samples (Stork 1991). Hijii (1983) found 200 to 3500/m^2 by the smoking method. The lower abundance in Fog1 within our samples is due to the collection method.

When the three samples are considered together, the dominant orders are Collembola (18.6% of the specimens), Diptera (18.4%), Coleoptera (13.6%), Hymenoptera (12.7%) and Psocoptera (11.4%). The frequencies of the other orders do not exceed 7%. Nematocera are more abundant than Brachycera and the majority of Hymenoptera were Formicidae (Table 1). Diptera and Coleoptera are represented respectively by 27 and 31 families; Hymenoptera are represented by at least 14 families (Chalcidoidea were considered a single taxon).

As reflected by the standard deviation of their abundance in subsamples within each fogging (Table 2), some abundant groups were not distributed evenly across the sample surface: Coleoptera, Nematocera, Collembola, and Psocoptera. Formicidae are patchy in Fog1 and Fog2, Nematocera in Fog2 and in Fog3, Acarina in Fog1 and Fog3, Thysanoptera in Fog2 and Homoptera in Fog3. Other groups, which are less abundant, are well spread throughout the collecting surface: Lepidoptera in the three samples, Acarina, Amphipoda, Dermaptera in Fog1 and Fog2, Orthoptera in Fog2 and Fog3. Among samples, some groups vary greatly in abundance: Collembola, Acarina and Nematocera; while others are quite constant: Hymenoptera, Brachycera, Lepidoptera and Dermaptera.

The abundance of Collembola varies greatly among foggings, from 6.3% to 24% to 21% of the sampled insects. A total of 29 species of Collembola were collected. The number of species among samples is nearly the same; but only nine species

Table 1. Absolute and relative frequencies of individuals belonging to major taxa collected by fogging.

Taxa	Fogging 1		Fogging 2		Fogging 3		Total fogging	
	Nber	%	Nber	%	Nber	%	Nber	%
1. Other Hymenoptera	144	6.5	188	5.9	197	4.2	529	5.5
2. Formicidae	126	5.7	471	14.8	94	2.0	691	7.2
3. Nematocera	612	27.5	323	10.1	299	6.4	1234	12.8
4. Brachycera	75	3.4	172	5.4	253	5.4	500	5.2
5. Heteroptera	63	2.8	61	1.9	49	1.1	173	1.8
6. Homoptera	40	1.8	64	2.0	233	5.0	337	3.5
7. Orthoptera	31	1.4	17	0.5	26	0.6	74	0.8
8. Coleoptera	269	12.1	301	9.4	736	15.8	1306	13.6
9. Araneae	197	8.8	174	5.5	277	6.0	648	6.7
10. Collembola	140	6.3	766	24.0	885	19.0	1791	18.6
11. Lepidoptera	10	0.4	17	0.5	31	0.7	58	0.6
12. Psocoptera	392	17.6	428	13.4	275	5.9	1095	11.4
13. Thysanoptera	28	1.3	65	2.0	145	3.1	238	2.5
14. Dictyoptera	42	1.9	9	0.3	81	1.7	132	1.4
15. Acarina	15	0.7	102	3.2	413	8.9	530	5.5
16. Amphipoda	2	0.1	5	0.2	30	0.6	37	0.4
17. Others	7	0.3	6	0.2	18	0.4	31	0.3
18. Pseudoscorpionida	1	0.04	0	0.0	44	0.9	45	0.5
19. Dermaptera	1	0.04	5	0.2	17	0.4	23	0.2
20. Larvae undetermined	32	1.4	17	0.5	87	1.9	136	1.4
21. Total	2227	100	3191	100	4190	100	9608	100

are common to the three samples, and three of them are abundant (Table 3). Four species are abundant in Fog2 and Fog3, but not in Fog1. The scarcity and absence of some species in the Fog1 may be due either to seasonal variation or to collecting technique. So the occurrence and the abundance of *Rastriopes fuscus* Yosii and *R*. sp. could characterize respectively Fog2 and Fog3 or could be a consequence of the sampling method or seasonal variation.

The low percentage of Collembola from Fog1 may be an artifact related to the collecting technique: according to Hijii (1983), one should wash the sheets with appropriate liquids after fogging in order to avoid the loss of microarthropods such as Collembola and Acarina. However, the percentage in Fog1 is high in comparison with the results of previous studies, and could be due to contamination of the sample by ground-dwelling Collembola jumping onto the sheets during fumigation and collection. However, Hijii (1983) and Watanabe & Ruaysoongnern (1989) found a great abundance of Collembola in Japan and Thailand respectively. Watanabe & Ruaysoongnern (1989) suggested that the great number of Collembola is related to seasonal flooding of the forest floor. Most Collembola found in fogging samples may also come from tree trunks, and/or from organic matter in the canopy (Stork 1988, Nadkarni & Longino 1990).

When comparing Collembola fauna from canopy and soil, their average richness is similar in the fogging samples (18 species) and in malaise trap sample (19 species) (Guilbert, unpublished data). Similarity in the ground and canopy fauna has also been observed in Costa Rica (Nadkarni & Longino 1990). However, Martin (1966) found 22 soil species compared to 10 species from crown stratum

Table 2. Simple statistics within samples of the major taxa sorted by sheets.

Taxa	Range	Sum	Mean	SD
Fog1				
Hymenoptera	0–9	144	4.80	2.63
Formicidae	1–17	126	4.20	3.45
Nematocera	7–40	612	20.40	7.29
Brachycera	0–5	75	2.50	1.55
Heteroptera	0–7	63	2.10	1.79
Homoptera	0–7	40	1.33	1.52
Orthoptera	0–5	31	1.03	1.30
Coleoptera	0–68	269	8.97	12.42
Araneae	1–21	197	6.57	4.04
Collembola	0–22	140	4.67	5.02
Lepidoptera	0–2	10	0.33	0.61
Psocoptera	1–54	392	13.07	12.74
Thysanoptera	0–4	28	0.93	1.01
Dictyoptera	0–6	42	1.40	1.61
Acarina	0–3	15	0.50	0.82
Amphipoda	0–1	2	0.07	0.25
Pseudoscorpionida	0–1	1	0.03	0.18
Dermaptoptera	0–1	1	0.03	0.18
Larvae	0–4	32	1.07	1.17
Fog2				
Hymenoptera	1–14	188	6.27	3.05
Formicidae	0–345	471	15.70	62.33
Nematocera	4–18	323	10.77	3.70
Brachycera	0–49	172	5.73	8.62
Heteroptera	0–10	61	2.03	2.11
Homoptera	0–14	64	2.13	3.03
Orthoptera	0–3	17	0.57	0.86
Coleoptera	3–24	301	10.03	5.05
Araneae	0–10	174	5.80	2.82
Collembola	0–73	766	25.53	19.30
Lepidoptera	0–2	17	0.57	0.77
Psocoptera	0–30	428	14.27	7.58
Thysanoptera	0–20	65	2.17	3.60
Dictyoptera	0–3	9	0.30	0.65
Acarina	0–9	102	3.40	2.79
Amphipoda	0–2	5	0.17	0.46
Pseudoscorpionida	0–0	0	0	0
Dermaptoptera	0–3	5	0.17	0.59
Larvae	0–3	17	0.57	0.77
Fog3				
Hymenoptera	2–14	197	6.57	2.74
Formicidae	0–11	94	3.13	2.67
Nematocera	4–24	299	9.97	4.54
Brachycera	2–23	253	8.43	5.24
Heteroptera	0–6	49	1.63	1.67
Homoptera	3–16	233	7.77	3.62
Orthoptera	0–3	26	0.87	0.97
Coleoptera	8–46	736	24.53	6.87
Araneae	2–26	277	9.23	5.26
Collembola	4–55	885	29.50	11.61
Lepidoptera	0–4	31	1.03	0.93

Table 2. Continued.

Taxa	Range	Sum	Mean	SD
Psocoptera	1–22	275	9.17	4.56
Thysanoptera	0–11	145	4.83	3.01
Dictyoptera	0–11	81	2.70	2.55
Acarina	2–46	413	13.77	9.28
Amphipoda	0–7	30	1.00	1.72
Pseudoscorpionida	0–5	44	1.47	1.48
Dermaptoptera	0–6	17	0.57	1.45
Larvae	0–9	87	2.90	2.37

in Ontario, and Hijii (1989) found a greater abundance of specimens of Collembola in the soil than in the canopy in Japan.

Two epiedaphic groups of Collembola, the Entomobryomorpha and Symphypleona, are very abundant in both New Caledonian canopy fogging and malaise trap samples. Most species belonging to these taxa found in our samples exhibit long claws, which probably constitute an adaptive character and when associated with their large ecological valency, allows invasion of all above-ground habitats. Nevertheless, some species probably live in epiphytic plants or suspended soil and may be restricted to the canopy (e.g., *Pseudoparonella (Pseudoparonella)* sp., *Lepidosira* (*Nusasira*) sp. and *Dicyrtomina* sp. 1 that occur in the fogging but not in the malaise trap samples).

Diptera represent 14.9% of specimens of the entire study. Nematocera are more abundant and diverse than the Brachycera. Ceratopogonidae, Chironomidae, Cecidomyiidae and Sciaridae are dominant and constitute 91.2% of Nematocera. Sixteen families of Brachycera were found, of which three accounted for 80.2% of the Brachycera individuals: the Chloropidae, Dolichopodidae and Drosophilidae.

With 27 families of Diptera, the canopy of the Rivière Bleue forest is poorer, particularly in Brachycera than forest in Ontario (44 families: Martin 1966); but it is richer than Queensland (12 families, mostly Nematocera: Basset 1991). The abundance of Diptera is greater in our samples (13.2 to 30.8%) than anywhere else (around 20%) except for Borneo (48 to 83%; Stork 1991). Family frequency depends on their activity around the tree: some flies pass through the sample area and are caught by the insecticidal cloud. Other families such as Phoridae, Chloropidae and Dolichopodidae are typically arboreal (Basset 1991); the occurrence of some families such as the Phoridae in only one of the two sites sampled may be related to differences in floristic composition. Greater abundance of Ceratopogonidae, Chironomidae, Cecidomyiidae and Sciaridae in Queensland, New-Caledonian and Bornean samples may due to the proximity of rivers or water spots (Stork 1991) as Rivière Bleue samples were collected 50 meters from a river.

The Cecidomyiidae belong to three different trophic guilds: predators, phytophages and mycetophages (Table 4). Mycetophage species (that belong mainly to the two primitive subfamilies Lestremiinae and Porricondylinae) are absent from the canopy, whereas they constitute 4.49% of malaise trap sample (EG, unpublished data). Larvae from the latter subfamilies are known to inhabit soil litter, mosses and dead wood. Their absence in the fogging samples is striking and should

Table 3. Number of specimens of Collembola per species and per collection obtained by fogging (Fog1, Fog2, Fog3).

Species	Fog1	Fog2	Fog3
Neanuridae			
Pseudachorutes tillieri Najt & Weiner	0	0	0
Hypogasturidae			
Xenylla sp.	0	5	0
Isotomidae			
Proisotoma sp.	0	1	0
Cryptopygus sp.	0	3	10
n.g. 1	0	0	2
Entomobryidae s.l.			
Pseudoparonella (*Plumachaeta*) *oceanica* Yoshii	4	0	18
Epimetrura sp.	29	127	124
Willowsia sp.	2	11	13
Salina (*Salina*) *oceanica* Yoshii	63	86	295
Pseudoparonella (*Oceaniella*) *shibatai* Yosii	16	13	96
Pseudoparonella (*Pseudoparonella*) sp. 1	1	6	8
Pseudoparonella (*Pseudoparonella*) *novae-caledoniae* Yosii	0	5	34
Lepidocirtoydes novae-caledoniae Yosii	0	0	5
Pseudoparonella (*Oceaniella*) *griseocoerulea* Yoshii	8	0	4
Pseudosinella (*Austrocyrtus*) *speciosa* Yoshii	0	0	0
Lepidosira (*Nusasira*) *vicina* Yoshii	2	11	15
Seira sp.	2	0	0
Pseudoparonella (*Pseudoparonella*) sp. 2	0	0	4
Lepidosira (*Nusasira*) sp.	0	6	4
Lepidosira sp. 1	0	0	3
Lepidosira sp. 2	0	1	0
Pseudoparonella (*Oceaniella*) *bicincta* Yoshii	1	0	0
Entomobrya (*Entomobrya*) sp.	1	0	0
Sminthuridae			
Parasphyrotheca sp.	1	15	15
Sphaeridia sp.	0	0	0
Sphyrotheca sp. 1	1	27	0
Sphyrotheca sp. 2	2	0	0
Bourletiellidae			
Bourletiellidae n.g.	0	1	0
Rastriopes fuscus Yosii	4	128	0
Rastriopes sp.	0	0	119
Dicyrtomidae			
Dicyrtomina sp. 1	1	37	10
Dicyrtomina sp. 2	2	283	106
Total	140	766	885

be further investigated. It could be related either to seasonal variations or to the canopy microclimate. The samples are also characterized by the reverse proportions in the two major predator genera (Table 4). This result is similar to observations in Europe where *Trisopsis* is mainly confined to the forest litter while *Lestodiplosis* has a broader ecological valence (MB, unpublished data). The phy-

Table 4. Trophic guilds of Cecidomyiidae from canopy (Fog1) and ground layers (malaise trap).

Trophic guild	Taxa	Fogging percentage	Malaise percentage
Predators	Cecidomyiinae		
	Trisopsis	9.24%	28.41%
	Lestodiplosis	14.55%	5.98%
Mycophages	Porricondylinae	0.%	1.09%
	Lestremiinae		
	Micromyiini spp.	0.%	3.08%
	Lestremiini spp.	0.%	0.32%
Phytophages	Cecidomyiinae	76.21%	61.12%
Total specimens		149.	1556.

tophagous Cecidomyiidae represent 76.5% in the canopy, vs. 61.1% at the soil level.

The Coleoptera are the most diversified order in terms of number of families (31). Only 16 families are present in both Fog1 and Fog3; most of the other families are represented by fewer than five specimens each in a single sample. There were fewer families than in Queensland (54 families: Basset 1991) or in Amazonian samples (57 families: Erwin 1983). As in those regions and in Panama, the Curculionidae, Corylophidae, Chrysomelidae and Staphylinidae are the most abundant (Basset 1991, Erwin 1983, Erwin & Scott 1980). Pselaphidae are more abundant in our samples than in any other published results. Coccinellidae are more abundant than in other regions (Basset 1991, Erwin & Scott 1980). In contrast to Queensland and Zaire, no Scolytidae and few Cerambycidae were found (Basset 1991, Sutton & Hudson 1980).

Most Hymenoptera collected belong to Parasitica and Formicidae. Formicidae are dominant with 7.2%, whereas other Hymenoptera represent 5.5% of the three fogging samples. Very few Symphyta are present, all of them belonging to the Sphecidae. Formicidae constitute 5.7, 14.8 and 2.0% of the specimens in each fogging sample. They are represented by 14 species and 7 genera, 11% of the genera cited by Taylor (1987) for the whole territory. *Paratrechina,* with 42.2% and *Camponotus,* with 16.4% of the total Formicidae in the Fog1, are the most abundant genera. The presence of *Pheidole,* which is terricolous, reflects the occurrence of epiphytes and suspended soil in the trees. Although not cited by Taylor (1987) and up to now unknown in New Caledonia, *Crematogaster* has been found in the fogging samples and, therefore, occurs in the canopy. Representatives of *Iridomyrmex, Monomorium* and *Adelomyrmex* are scarce.

Formicidae are less abundant here than in Amazonian or Bornean samples (Erwin 1983, Adis et al. 1984, Stork 1988). As in Queensland, the paucity of ants is more typical of temperate forests than of tropical ones (Basset 1991). Parasitica like Scelionidae are usually abundant in tropical samples (Basset 1991, Noyes 1989), but are poorly represented here; because they reflect the abundance of their host taxa in the canopy, the latter are probably scarce in New Caledonia.

The Psocoptera, although usually scarce in fogging samples (1.9 to 12.1% in previous studies), represent 11.4% of the three samples. Psocoptera abundance is higher in Japan and Ontario (Hijii 1986, Martin 1966). They are more frequently found on tree trunks than in the canopy. Stork (1987) suggested that the distance of the sheets from the tree trunks may considerably influence Psocoptera collection efficiency, and their abundance in the Rivière Bleue rainforest may indicate a high density of tree trunks when compared with other forests.

Eleven families of Araneae were found. The Clubionidae, Lyniphiidae, Salticidae and Pholcidae are the most abundant with respectively 29.4%, 19.8%, 12.7% and 12% of the specimens. No other family exceeds 3.5%. The greater abundance of Araneae here than in other regions of the world may be related to the reduced abundance and richness of Formicidae, which may supplant the spiders in the canopy (Majer 1990). However, Stork found 21 families in Bornean samples (Stork 1991). Fewer Salticidae (6.6%) and more Thomisidae (38%) were recorded in Ontario (Martin 1966). Theridiidae (1%) are less abundant than in Queensland (31.2%: Basset 1991) and Borneo (22.9%: Stork 1991).

The Acarina are more abundant in Fog2 and Fog3, possibly because the sheets from these foggings were washed. With 5.5% of all the specimens from fogging samples, they are more abundant than in most other regions. However, they were recorded as a dominant group in Japan (Hijii 1983, 1986), in Ontario (Martin 1966) and in canopy organic matter in Costa Rica (Nadkarni & Longino 1990).

Other arthropod orders, Lepidoptera, Dermaptera and Neuroptera, are scarce in the three fogging samples. Some groups, such as Thysanoptera, Pseudoscorpionida, Amphipoda, are scarce in Fog1 and Fog2 and abundant in Fog3. This variation may be related to seasonal flooding, as observed by Watanabe & Ruaysoongnern (1989) for Thysanoptera in Thailand, or to the floristic composition of the canopy.

Discussion

New Caledonian Fauna Composition.—The abundance of Collembola and Acarina varies strongly among samples from other locations (see literature cited above). This variation may be related to canopy cover, presence of suspended soil or to the method used by the authors. These taxa are usually not abundant when collected by fogging. Acarina were the most abundant group collected by hand by Nadkarni & Longino (1990). According to some authors, variations of abundance and composition of soil faunal taxa such as Collembola are due to transfer between canopy and soil layers (Adis et al. 1984).

The abundance of Hymenoptera, Heteroptera, Orthoptera, Araneae, Lepidoptera and Psocoptera exhibits little variation in the three Caledonian samples. They seem to be unaffected by changes in the composition of the flora between the two sites, or by seasonal variations. These taxa are more abundant in the dry season in Thailand (Watanabe & Ruaysoongnern 1989). According to Basset (1991), some arthropod taxa are more abundant during flowering and leaf flush in Queensland.

Our observations are based upon three samples only and major taxa and sampling biases may be expected. For example, the abundance of Formicidae in the Fog2 is due to an aggregation of one species which represents 73% of all Formicidae in this fogging. Stability in abundance of major taxa could hide variations of composition inside these taxa. Further sampling is needed to test these observations.

Conclusions

Rivière Bleue's fauna shows differences with other faunas in the world at family levels. In addition, it differs from faunas of other forests in New Caledonia (EG, unpublished data) and at the species level (Collembola) between two locations in the same forest. The arthropod fauna of New Caledonia is characterized by the importance of the Psocoptera and of the Diptera. It is similar to the fauna of Queensland because of the importance of the Psocoptera, and of the Bornean fauna, which is characterized by the importance of the Diptera.

Composition of the sample is influenced by multiple variables of the sampling method: escape of strong fliers from the insecticidal cloud (Noyes 1989), death of insects under bark and inside epiphytes without falling down, position of the sheets laying on the ground or suspended, collecting technique, position of the fogger and collecting time. All these factors possibly contribute to obfuscate general patterns that may have historical (i.e., biogeographical), as well as functional (i.e., ecological), explanations. Fogging and sorting methods should be standardized in order to eliminate these sources of noise and to increase significance of observed patterns.

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Literature Cited

Adis, J., Y. D. Lubin & G. Montgomery. 1984. Arthropods from the canopy of inundated and Terra firme forest near Manaus, Brazil, with critical considerations on the pyrethrum-fogging technique. Studies Neotr. Fauna Environ., 19: 223–236.

Basset, Y. 1988. A composite interception trap for sampling arthropods in tree canopies. J. Aust. Entomol. Soc., 27: 213–219.

Basset, Y. 1990. The arboreal fauna of the rainforest tree *Argyrodendron actinophyllum* as sampled with restricted canopy fogging: composition of the fauna. The Entomologist, 109: 173–183.

Basset, Y. 1991. The taxonomic composition of the arthropod fauna associated with an Australian rainforest tree. Aust. J. Zool., 39: 171–190.

Bonnet de Larbogne, L., J. Chazeau, A. Tillier & S. Tillier. 1991. Milieux naturels néo-calédoniens: la Réserve de la Rivière Bleue. pp. 9–17. *In* Chazeau, J. & S. Tillier (eds.). Zoologia Neocaledonica, 2. Mém. Mus. natn. Hist. nat., Paris.

Erwin, T. L. 1983. Beetles and other insects of tropical forest canopies at Manaus, Brazil, sampled by insecticidal fogging. pp. 59–79. *In* Sutton, S. L., et al. (eds.). Tropical rainforest ecology and management. Blackwell Press, Oxford.

Erwin, T. L. 1989. Canopy arthropod biodiversity: a chronology of sampling techniques and results. Rev. Entomol. Peruana, 32: 71–77.

Erwin, T. L. & J. C. Scott. 1980. Seasonal and size patterns, trophic structure and richness of Coleoptera in the tropical arboreal ecosystem: the fauna of the tree *Luehea seemannii* Triana and Planch in the canal zone of Panama. Coleopt. Bull., 34: 305–321.

Gagné, W. C. 1979. Canopy-associated arthropods in *Acacia koa* and *Metrosideros* tree communities along an altitudinal transect on Hawaii island. Pac. Ins., 21: 56–82.

Hijii, N. 1983. Arboreal arthropod fauna in a forest: seasonal fluctuations in density, biomass, and faunal composition in a *Chamaecyparis obtusa* plantation. Jap. J. Ecol., 33: 435–444.

Hijii, N. 1986. Density, biomass, and guild structure of arboreal Arthropod as related to their inhabited tree size in a *Cryptomeria japonica* plantation. Ecol. Res., 1: 97–118.

Hijii, N. 1989. Arthropod communities in japanese cedar (*Cryptomeria japonica* D. Don) plantation: abundance, biomass and some properties. Ecol. Res., 4: 243–260.

Majer, J. D. 1990. The abundance and diversity of arboreal ants in northern Australia. Biotropica, 22: 191–199.

Martin, J. L. 1966. The insect ecology of red pine plantations in central Ontario. IV. The crown fauna. Can. Entomol., 98: 10–27.

Myers, N. 1988. Threatened biotas: "hot spots" in tropical forests. The Environmentalist, 8: 187–208.

Nadkarni, N. M. & J. T. Longino. 1990. Invertebrates in canopy and ground organic matter in a neotropical montane forest, Costa Rica. Biotropica, 22: 286–289.

Noyes, J. S. 1989. A study of five methods of sampling Hymenoptera (Insecta) in a tropical rainforest, with special reference to the Parasitica. J. Nat. Hist., 23: 285–298.

Roberts, H. F. 1973. Arboreal Orthoptera in the rain forest of Costa Rica collected with insecticide: a report of the grasshoppers (Acrididae) including new species. Proc. Acad. Nat. Sc., Philadelphia, 125: 46–66.

Southwood, T. R. E., V. C. Moran & C. E. J. Kennedy. 1982. The richness, abundance and biomass of the arthropod communities on trees. J. Animal. Ecol., 51: 635–649.

Stork, N. E. 1987. Arthropod faunal similarity of Bornean rain forest trees. Ecol. Entomol., 12: 219–226.

Stork, N. E. 1988. Insect diversity: facts, fiction and speculation. Biol. J. Linn. Soc., 35: 321–337.

Stork, N. E. 1991. The composition of the arthropod fauna of Bornean lowland rain forest trees. J. Tropical Ecol., 7: 161–180.

Sutton, S. L. & P. J. Hudson. 1980. The vertical distribution of small flying insects in the lowland rain forest of Zaire. Zool. J. Linn. Soc., 68: 111–123.

Taylor, R. W. 1987. A checklist of the ants of Australia, New Caledonia and New Zealand (Hymenoptera: Formicidae). CSIRO Aust. Div. Entomol. Rep., 41: 1–92.

Watanabe, H. & S. Ruaysoongnern. 1989. Estimation of arboreal arthropod density in a dry evergreen forest in northeastern Thailand. J. Trop. Ecol., 5: 151–158.